The importance of tacit knowledge in AI implementation

Medical practice example

Introduction

The great strides made lately in the field of Artificial intelligence (AI) allow it to pervade all aspects of our life. At first glance, digital assistants, robots, expert systems and other autonomous devices seem capable of performing just about any human activity, perhaps even better than humans can. However, a closer look reveals that the most advanced systems are starting to show their limitations, in the form of questionable judgement or even catastrophic results.

Let's bear in mind that unlike a human being, a machine has no natural capabilities; any automatic "behavior" is programmed (or hard-wired) and configured, including the ability to "learn" to recognize patterns or conditions and apply criteria to reach "decisions".

Let's also bear in mind that these kinds of automatic "behaviors" have been with us since the first computerized operations in the 1950s; what's different today are two distinct properties: both the sheer power of today's technology (execution speed, natural language processing, Big Data, etc.) and its ability to perform "self-configuration", i.e. enhancing and adapting its parameters by itself.

Example

A medical practice, having noticed that managing patient flow has become quite time-consuming for the office assistant, decides to create a digital assistant to manage the flow. With this goal in mind, an AI development company is consulted to develop an appropriate technological solution.

For the doctors, the solution seems "obvious": implement a digital assistant that does automatically everything the (human) assistant does now, in other words "simply" greet the patients and, as needed, let them know how long they will wait until the doctor can see them.

Besides, the practice already has a computerized appointment calendar, although appointments are made by telephone and entered by the assistant. All that should need to be done is enhance the existing system to allow appointment scheduling on-line.

However, much to their chagrin, the AI company informs them that this requirements statement is far too vague, that it includes numerous unspoken assumptions because the "algorithms" (greet, estimate waiting time, make an appointment) are currently "executed" in the assistant's head, guided by many years of experience and professional judgement, whereas a machine must be given precise rules covering "normal" cases and all the exceptions.

So, an initial scoping phase ensues in order to:

1. Understand and map out the knowledge domain that is "in the head" of the practice's assistant and thoroughly specify the intended behavior of the final system;
2. Organize the development as a project including prioritizing the implementation of the various desired functions, ranking them as "essential" and "advanced", thus allowing them to choose the most appropriate technologies.

After two interviews – short and highly focused – with the practice's assistant, we were able to set off again on good footing, relying on the assistant's essential knowledge accumulated over the course of many years' experience…

Summary of the practice's assistant's essential knowledge

Recognizing the patient:

- "The patient's identity must be recognized, **as soon as they enter the office**, and it must be determined whether they have an appointment or not"

The patient's mindset:

- "The medical practice's patients are also **paying customers**, regardless of whether they pay directly (cash) or indirectly (insurance)"
- "The **perceived** time a patient spends waiting is not experienced objectively: the threshold of its becoming "intolerable" may depend on the patient's background (gender, age, social standing, etc.)"
- "A feeling of injustice can be triggered when a patient sees another person called ahead of them; they may feel that they are being treated unfairly or even as though they were singled out ☹ "

The practice must comply with appointment scheduling principles, such that they are clear and understood by the patients:

- "It is absolutely required to inform patients of the waiting time before being seen by the doctor, as well as the underlying **principles**:
    1. Patients with appointments are given preferential treatment compared to those who show up without an appointment;
    2. Patients who arrive on time are given preferential treatment compared to those who arrive late."
- "Thus, it is not simply the order in which patients arrive in the waiting room that sets the order in which they are seen by the doctor, but rather their appointment times, and compliance with those times, combined with arrival times"

The notion of **emergency** in the medical field:

- "We are no longer dealing with perceived time: a medical emergency entails a strong constraint with respect to objectively **measured** time, for the practice and the patient: the patient must be treated ASAP!"
- "Patients must be seen in an order complying with the principles of appointments, all the while remaining flexible in case of medical emergency"

The practice must welcome and inform:

- "The practice must contribute to its patients' **comfort**, to ensure that their visit is pleasant (or at least, less unpleasant), and tell each patient approximately how long (**estimated waiting time**) until they will be seen"
- "Lastly, it would be desirable to be able to predict the impact of delays experienced during the day, in order to warn later patients so that they don't have to show up until a time closer to the actual time when they can be seen, thus shortening their waiting time"

Sample solution based on our proposition

Given this new information, an updated version of the requirements statement can be produced (highlights):

- **Recognize the patient's identity, without the patient having to perform any conscious operations, as soon as they arrive in the office**
    - *(It is noted that this function will require making a choice between several possible technological solutions, with a thorough cost-benefit analysis)*
    - *(It is noted that the solution scope has been narrowed to explicitly not include collecting any personal data such as, but not limited to, fingerprints, facial features, voice, etc.)*
- Ascertain whether the patient has an appointment (made prior to their arrival) or not
    - *(It is noted that this function implies that the new system must interface with the practice's existing on-line appointment calendar)*
    - If the patient has an appointment, ascertain whether they have arrived "on time" (calculated with a tolerance range)
    - If the patient does not have an appointment, put them in the waiting list after patients with appointments (according to an algorithm specified by the practice)
    - **(Advanced function, assess the appointment-less patient to determine whether it's a case of medical emergency requiring immediate attention)**
- If the patient arrives on time for their appointment (i.e. within the tolerance range specified by the practice), put them in the waiting list behind other patients with earlier appointments still waiting to be seen
    - *(It is noted that arriving early does not enable a patient to move forward in the waiting list except in one specific case, below)*
- If the patient arrives late for their appointment (i.e. outside the tolerance range):
    - The first succeeding patient (i.e. with an appointment whose time is closest to the current moment) already in the waiting room will be seen
        - *(Thus another unspoken goal will be met, that is to optimize the doctors' time as well, avoiding as much as possible any unplanned downtime between appointments)*
    - A patient arriving late forfeits their place in the waiting list and will be put into the first available slot that does not penalize any patients who arrived on time
        - *(It is noted that this particular algorithm is likely to require several trials under actual conditions before finding the best balance)*
- Each patient will be informed of their individual estimated waiting time, based on their place in the waiting list
    - To begin, this time will be calculated based on theoretical appointment durations
    - As the new system operates and collects actual data, it should be able to both keep up-to-date "average" durations (calculated based on hundreds if not thousands of appointments) and also recalculate in real time (assuming that several appointments have already been conducted) based on measured duration of the actual day, updated at the end of each appointment

- **(Advanced function: detect abnormal waiting times (longer or shorter than usual) during the day and warn patients with later appointments so they can delay or advance the time for coming to the office)**
- **(Advanced function: be able to predict longer than usual waiting times due to external events (traffic issues, doctors arriving late, emergencies, etc.) and warn all patients including the day's first patients so they can adjust the time for coming to the office)**
- **(Highly advanced function: perform workload balancing among the doctors in the practice by reallocating patients among qualified doctors within the practice)**

[General note: functions written in bold are those that must be implemented using AI technologies, i.e. difficult to implement using traditional technologies.]

Summary of our approach

In order for AI to enhance and enrich human life, we propose looking at it along several axes:

1. Recognize that implementing an AI system requires a *project*, just like all other types of computerization:
    a. Such a project will usually follow an "Agile" lifecycle, that is, iterative and incremental
2. Recognize the distinction between the *means* (the technology) and the *outcome* (also called "intentions"), which requires deep understanding of the underlying knowledge domain:
    a. Automatic natural language processing is not an end unto itself, but is rather a means to accomplish a greater task:
        i. For instance, seeking information "Alexa, find a restaurant", operating a telephone "Siri, call Mom", driving a car "turn left at the next intersection", etc.
    b. This (like any other project) requires us to analyze and specify the targeted scope of action and the desired outcome(s), and to adapt a generalized technology to our specific needs:
        i. For example, for a system designed to make it easier for a company's customers to interact with the company, we must specify **which** customers, **when**, to do **what**, etc.
3. Recognize the distinction between a *project* (a set of coordinated human activities to achieve a specific desired outcome) and its *outcome* (the system that is produced):
    a. For example, "Implement an AI system" is not a well-defined project, whereas "Provide our retail customers with a digital assistant enabling them to choose the product that best meets their needs" is (probably) one.

Who are we

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